Science and Innovation in BBSRC-sponsored Institutes

The Next Ten Years

Sustainable Agriculture and Land Use
Institute of Grassland and Environmental Research
Rothamsted Research
John Innes Centre (Plant and microbial sciences)

Animal Health and Welfare
Institute for Animal Health
Roslin Institute

Biomedical and Food Sciences
Babraham Institute
Institute of Food Research

bbsrc
biotechnology and biological sciences research council

Contents

The Biotechnology and Biological Sciences Research Council (BBSRC) is the UK's principal public funder of basic and strategic research across the biosciences. For more information, please visit **www.bbsrc.ac.uk**

It is funded primarily by the Science Budget through the Office of Science and Technology (OST, Department of Trade and Industry); and is part of the Research Councils UK (RCUK) partnership.

Contact: Dr Paul Burrows
Email: paul.burrows@bbsrc.ac.uk

November 2005

Science and Innovation in BBSRC-sponsored Institutes

The Next Ten Years

This document sets out an overview of the science and innovation in BBSRC-sponsored institutes over the next decade.

It shows how they will continue to help to deliver the aims and objectives of the BBSRC's Strategic Plan[1], and the wider aspirations of the Government's Ten Year Science and Innovation Framework[2].

Institutes sponsored by BBSRC:

Sustainable Agriculture and Land Use

Institute of Grassland and Environmental Research (IGER) – Aberystwyth
Rothamsted Research (RRes) – Rothamsted, Harpenden, Hertfordshire
John Innes Centre (JIC) – Norwich Research Park

Animal Health and Welfare

Institute for Animal Health (IAH) – Compton, Near Newbury, Berkshire
Roslin Institute (RI) – Roslin, Midlothian

Biomedical and Food Sciences

Babraham Institute (BI) – Babraham, Cambridge
Institute of Food Research (IFR) – Norwich Research Park

For more information on institutes sponsored by BBSRC please visit:
www.bbsrc.ac.uk/about/centres

[1] www.bbsrc.ac.uk/about/pub/policy/strategic.html
[2] www.hm-treasury.gov.uk./media/33A/AB/spend04_sciencedoc_1_090704.pdf

Introduction and role

BBSRC invests around £230M in research each year, two thirds of which is awarded to universities as research grants, and one third supports seven institutes in the form of core and competitive funding. The institutes employ a total of 3000 people – mostly scientists and technical staff, and have an annual turnover of £150M with assets and facilities worth £500M[3].

All leading knowledge-based economies benefit from having a diversity of research providers – universities, public sector institutes, charities and private sector laboratories. BBSRC institutes are therefore part of the healthy diversity of the UK Science and Engineering Base. They maintain national capability in key areas of research and work with other organisations to provide high quality science and training with strong knowledge transfer activities.

The added value of institutes rests in their mission-driven focus in specific areas of research where they take a multidisciplinary approach that is typically more strategic and longer-term than that found in the university sector.

Linking scientific excellence and knowledge transfer

The institutes enhance the UK's international standing in science. They are some of the country's leading centres of excellence in animal, plant and microbial sciences, and often represent the UK in major multinational projects. Their research-centred environment enables strong interactions with industry, Government Departments and other stakeholders, and generates knowledge transfer activities that meet policy and business needs.

- In the period 1997-2004 BBSRC institutes published over 200 papers in the *Nature* family of journals: over 100 in *Nature* itself; and more than 50 in *Science*.
- Around 40% of the scientific papers published by institutes are with international partners.
- Institutes are involved in over 200 EU funded collaborations each year, worth more than £7.25M to the institutes.
- The institutes are partners in an average of 55 LINK projects at any one time.
- Institutes are also partners each year in more than 80 other collaborative projects with industry.

Supporting the knowledge-based economy

Alongside the university sector, institutes provide knowledge, public value science and skilled people essential for the UK economy, public services, policy development, and improved quality of life. Training the next generation of researchers – particularly in interdisciplinary areas – is a vital aspect of institute work.

- In 2005, 15 spin-out companies were working on the basis of BBSRC institute science, employing over 80 staff.
- In the period 2000-2004 the institutes won competitive research income of £70M from industry and £14M from research charities.
- Since 2001, income to institutes from Intellectual Property (IP) has exceeded £7M.
- In 2004-05 institutes were involved in around 200 industrial consultancies with c.160 industrial customers.
- In any one year there is an average of 350 Doctoral students in place across BBSRC institutes.

[3] See page 25 for overview of Governance and assessment of BBSRC's institutes.

The Highlights section on page 20 illustrates some of the significant scientific achievements of BBSRC institutes over the last decade.

Providing crucial national capability

The focused missions, multidisciplinarity, long-term research and unique resources and facilities of the institutes provide a critical national capability in key areas, for example plant science, animal health, sustainable land use and diet & health.

- Rothamsted Research has internationally unique data on crop and soil science extending back over 160 years. This is a vital resource in understanding impacts of climate change.
- The Institute of Grassland and Environmental Research has unique field-scale facilities to study the movement of nutrients and pollutants through livestock-based land use systems and to model their impacts on soil, water and atmosphere.
- The Institute for Animal Health has containment facilities unrivalled in the UK, and houses the only UK facility for work with live foot-and-mouth disease virus.
- The Roslin Institute leads the UK contribution to international research effort in farm animal genetics and genomics, and hosts ARK-Genomics, a national collaborative centre that provides a key resource for UK scientists working on farm animal species.
- The Institute of Food Research is the only UK institute integrating research on nutrition and the GI tract and relating these to the structure/composition of food. This is helping to develop foods and strategies to combat diet-related diseases.
- The John Innes Centre is a world-leading centre for basic plant science.
- The Babraham Institute provides a national focussed capability in cell biology with a particular emphasis on cell communication and signalling, and gene regulation including epigenetics.

Providing independent research and advice for Government

The institutes' critical mass of knowledge and expertise provides independent research and advice to Government in crucial policy areas such as the control of animal disease and food safety.

- In the period 2000-2004 the institutes won competitive research income of c.£180M from the public sector, the vast majority of this from Government Departments.
- Institute experts play a major role in advising the Government and influencing policy development. They sit on Advisory Committees, working groups or Commissions for Defra, FSA, DoH, DTI and ODPM.
- The Institute for Animal Health played a vital role in the national response to the foot-and-mouth epidemic in 2001.

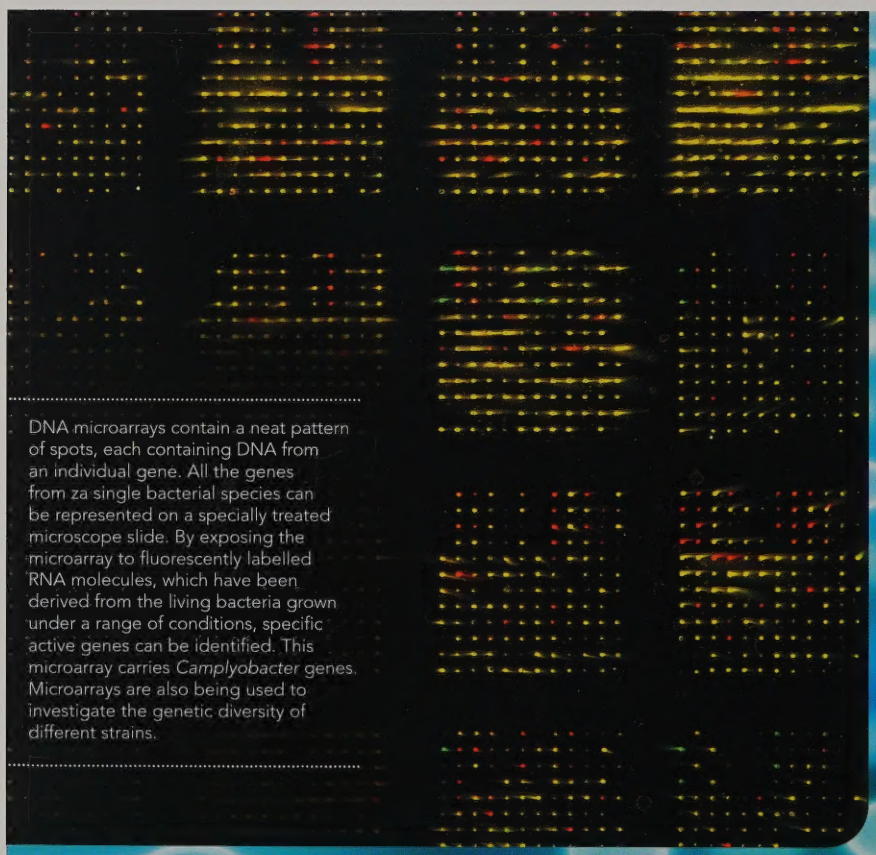
Science in BBSRC-sponsored Institutes: The Next Ten Years

BBSRC's institutes will continue to develop insight and opportunities from their strong platform in bioscience research – from structure and function of biologically relevant molecules, through cellular processes and the organisation of cells in tissues, to the development and behaviour of whole organisms, populations and ecosystems.

They will provide new knowledge, capacity and trained people in three overarching strategic areas of research:

- **Sustainable Agriculture and Land Use**
- **Animal Health and Welfare**
- **Biomedicine related to human well-being (including food safety, and diet & health)**

The next ten years will see exciting new advances fuelled by insights from the genomics revolution and the drive towards quantitative and 'systems' approaches in bioscience. To seize these opportunities, bioscientists in the institutes are increasingly working with physical scientists and mathematicians and in partnerships with researchers in economics and social science to provide multidisciplinary solutions to major challenges that face the UK. Some examples of these appear opposite.



DNA microarrays contain a neat pattern of spots, each containing DNA from an individual gene. All the genes from za single bacterial species can be represented on a specially treated microscope slide. By exposing the microarray to fluorescently labelled RNA molecules, which have been derived from the living bacteria grown under a range of conditions, specific active genes can be identified. This microarray carries *Camplyobacter* genes. Microarrays are also being used to investigate the genetic diversity of different strains.

Institute research will help to meet some of the major challenges ahead

Challenge	Examples of institute research themes
Minimise adverse effects of climate change on UK farming and food security	▪ Research to understand the genetic and other determinants of crop traits such as drought- and heat-tolerance [1][4]. ▪ New tools and diagnostics for plant and animal breeders [1, 2]. ▪ Integrated land, crop and atmosphere models to predict impacts of climate change [1].
Develop more sustainable land use and stewardship of natural resources such as soil and water	▪ Predictive models of nutrient flows, pollutants, spread of pests and disease [1, 2]. ▪ Biology of how plants and animals utilise resources [1]. ▪ Investigating plant-soil-microbe interactions [1].
Counter economic and health threats from diseases of plants, animals and people, for example as a result of increasing free trade, global travel, climate change or bioterrorism	▪ Genomics and biology of pathogens and host-pathogen interactions [1, 2]. ▪ Immunology/vaccinology for 'exotic' viral diseases [2]. ▪ Biology and epidemiology of animal diseases communicable to humans [2, 3]. ▪ Detection and control of plant and animal disease [1, 2].
Develop low-carbon sources of renewable energy	▪ Genetics and agronomy of fuel crops [1]. ▪ Biology of microbial fuel cells [1].
Use plant and microbial products to replace petrochemicals and as feed-stocks for industry	▪ Metabolism of secondary plant products e.g. for biodegradable starches, plastics and oils [1].
Ensure a safe and healthy food supply	▪ Genomics and biology of food poisoning bacteria [3]. ▪ Nutritional and other properties of plant-derived dietary components [3].
Develop new antibiotics to counter increasing resistance – e.g. MRSA	▪ Genetics and synthesis of natural antibiotic production in *Streptomyces* [3]. ▪ Enabling strategies to develop novel agents [3].
Tackle obesity; diet-related causes of diabetes, coronary heart disease and some cancers; healthier ageing	▪ Diet-gene interactions, genetic predispositions to some cancers [3]. ▪ Predictive models of food digestion [3]. ▪ Food-medicine interactions [3].
Capitalise on the UK's lead in stem cell science to develop new treatments for human diseases	▪ Role of epigenetic factors in cell development and of cell signalling in cell growth and function [3]. ▪ Use of embryonic stem cell derived hepatocytes in *in vitro* toxicity testing.

[4] Numbers in square brackets indicate the relevant strategic area; 1 = Sustainable Agriculture and Land Use; 2 = Animal Health and Welfare; 3 = Biomedicine related to human well-being (includes food safety, diet & health).

Sustainable Agriculture and Land Use

See BBSRC Strategic Plan sections Integrative Biology, Sustainable Agriculture and Tools and Technology:
www.bbsrc.ac.uk/about/pub/policy/strategic.html

The rural landscape is vital to the UK economy and our nation's quality of life. Around 75% of the UK land area is used for livestock or arable farming, providing 60% of our food, supporting thousands of individual farming businesses and underpinning food chain and other land-based industrial sectors. Growing demand for sustainable, environmentally friendly farming, and increased awareness of 'food miles' reinforces the need for local, reliable, safe, high-quality and traceable food. In addition, the rural landscape is the working and living environment for millions of people, provides amenity and recreation for millions more and is a pillar of the multi-billion pound tourist industry. All these sectors already benefit from research at BBSRC institutes. Looking ahead, the demand for food in the developing world will continue to escalate and the resilient, productive soils of Europe (including UK), coupled with a favourable climate, will be critical for global food production in decades to come. This underlines the need for strategic research to take the necessarily long-term view of science-based and tested strategies for sustainable land use.

High quality plant and microbial science

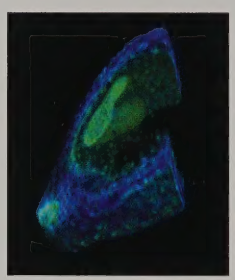
We need to know more about the basic workings of plants and microbes (and their interactions) if we are going to be able to meet the strategic goals of reducing non-renewable inputs to agriculture, and maintaining or increasing food production and non-food crops without cultivating more marginal land or wild areas. High quality basic science is essential to illuminate the biology of these organisms, and in doing so to provide leads for new strategies and new genes and traits of relevance to more sustainable agriculture and land use. There are strong plant and/or microbial science programmes at a number of institutes, particularly at the world-leading John Innes Centre (JIC).

JIC scientists have played leading roles in international work that has sequenced *Arabidopsis thaliana* and rice – both good 'models' for understanding the more complex genetics of crops such as brassicas, wheat and maize, and the latter a staple for around a quarter of the world's population. They have also developed tools and technologies to accelerate breeding programmes for crop improvement.

Research at JIC has elucidated some of the fundamental processes involved in the regulation of flowering time, the development of roots and shoots, and plant defence against disease. Substantial practical benefits are likely to ensue from this knowledge – for example the ability to control flowering time in crops to avoid bolting, to advance or delay flowering in the season or to make flowering and seed production more synchronous.

JIC is also a world leader in the genetics of the bacterium *Streptomyces coelicolor* and, with the Sanger Institute, has sequenced its genome. This genus is the source of half of the antibiotics in use today, and detailed genome analysis is revealing enormous potential for the production of many more novel bioactive molecules (see also 'Novel therapeutics and treatments', page 13).

Over the next ten years JIC and other institutes will increasingly take a systems approach to plant and microbial science. A priority will be to translate knowledge from model species such as *Arabidopsis* into practical options, new genes and tools for crop improvement. Such work will feed into programmes at Rothamsted Research (RRes) and the Institute of Grassland and Environmental Research (IGER) where the genetics of nutritional quality of cereals and forage grasses, and resistance to drought, pests and disease are being identified. The aim is to develop crops that need less agrochemicals and have improved product quality. High quality plant science is essential for developing new varieties to meet climate change and new markets, including energy crops and other non-food uses.



Optical Projection Tomography enables digital sections though the *Arabidopsis* seed to expose the developing embryo and other structures inside it.

Less than 1% of all microbe species in complex natural environments such as soil, water or animal systems have been cultured in the laboratory. The uncultured 99% are a wealth of unexplored traits and novel bioactive molecules. A major challenge is to be able to study these organisms, access their genomes and understand their population dynamics. New approaches of 'metagenomics' involving detecting key genes or other DNA sequences directly from crude and complex samples are shedding light on 'unculturable' microorganisms. The expertise in genetics and microbiology at BBSRC institutes will increasingly use metagenomics in, for example, the soil or the gut/rumen, to access untapped microbial diversity and reveal community structures.

Going forward, institute-led science will reveal more about the interactions of microbial communities in soil and associated with plant roots. Evidence is accumulating that microbes in the plant rhizosphere (root/soil interface) can influence plant nutrition, growth, disease and abiotic stress. Manipulating the rhizosphere could improve crop growth and management with reduced non-renewable inputs. Supported by critical mass of expertise, programmes investigating these effects are underway in institutes.

Sustainable soil function

Soil is a vital natural resource and a key component of sustainability. This complex medium provides not only the basis for food production but also helps to protect the quality of water-courses, influence risks of flooding, enable disposal of waste materials and mitigate climate change through carbon sequestration.

Recognising the importance of soils, RRes and IGER have established a cross-institute programme in sustainable soil function, which will maximise benefit from shared expertise and facilities to unravel some of the complex chemical, physical and biological interactions in the soil. Long term field-based experimental resources at both RRes and IGER are key elements of this programme.

Biodiversity and reducing the environmental footprint of agriculture

Research at RRes, JIC and IGER aims to improve the efficiency with which crops use water and mineral nutrients. Ultimately this will enable reductions in demand for water and inorganic fertilisers without reducing yield or quality, thus improving the environment and increasing the competitive edge for producers and processors. Maintaining soil quality and limiting the flow of harmful materials to the wider environment is a vital component of this research and complements work at IGER and Roslin Institute (RI) on reducing nitrogen flow (a major source of diffuse water pollution) from crop and animal production systems.

Grazing animals sustain biodiversity in pastures, hills and uplands, but they may have a negative environmental impact, mainly due to their inefficient conversion of plants into meat and milk. Work at IGER is increasing our understanding of forage conversion efficiency, whilst minimising the risk of pathogens entering the food chain. IGER's research will inform novel forage breeding, management and feeding strategies to improve the safety and quality of food, and to protect the environment.

Sustainable production requires biodiversity in agricultural ecosystems for functions such as nutrient cycling, degradation of pollutants, pest control and crop pollination. New approaches to understanding and predicting the consequences of different land management practices on the function of soils and agri-ecosystems are being developed by multidisciplinary teams of ecologists, soil scientists, statisticians and modellers at RRes and IGER.

Sustainable animal production

The majority of the UK's agricultural land is used for animal production to provide chiefly meat and milk. Grazing pastures and uplands are a vital component of our valued rural landscape. We need to reduce the environmental footprint of animal production (fewer non-renewable inputs, less waste, less pollution) whilst improving product quality and safety.

Substantial improvements in the productivity of farm animal systems have been achieved over the past fifty years largely through quantitative genetic research; in which the RI is a world leader. In future a leading priority for RI will be to identify genetic loci, networks of genes and their effects and interactions to further improve the efficiency with which feed is converted to meat and other animal products. Greater efficiency of conversion leads to reduced inputs (saving on materials and transport) and less waste and pollution are produced. This work on basic animal genetics complements that at IGER on forage composition and digestion.

There is also significant complementarity between the sustainable animal production systems and the area of animal health and welfare (see page 9). Reproductive health is essential to the sustainability and a key determinant of animal welfare. Indeed, reproductive failure is a significant problem for the farm animal sector; for example, fertility in the dairy herd has been declining by about 1% per annum for more than twenty years. Research at RI to understand the genetic control of reproductive and other performance traits will inform new breeding strategies that accord reproductive fitness the priority required for sustainability.

Combating disease

Diseases of plants and animals are a major constraint on sustainability, often requiring interventions with chemical control agents such as pesticides or drugs. Over the next ten years combating disease will remain a major element of institute research (see also page 9); two examples of particular relevance to sustainable agriculture are:

- Research at IAH will lead to the development of low cost, effective vaccines for major livestock diseases to replace less effective vaccines and chemicals that require repeated or continuous administration. This will reduce environmental damage, decrease residues in foods and reduce the development of pathogens resistant to antibiotics.
- At RRes there is a strong focus on understanding fungal diseases of plants – a major cause of crop losses worldwide. Using genome sequence data for important fungal diseases of cereals, researchers are unravelling the regulation of pathogenesis and important targets for new control strategies.

Over the next ten years research at BBSRC institutes on sustainable land use will:

REWARDS

- Provide science based options to reduce dependence on non renewable inputs to agriculture such as fossil carbon (fuel and fertilisers), water and phosphorus.
- Improve the use of plants and microorganisms to produce renewable energy, sustainable sources of raw materials for industry and high value products.
- Provide models to predict effects of climate change on UK land use patterns, and identify new market opportunities and options for minimising undesirable effects.
- Provide new tools and genetic resources, to accelerate crop and livestock improvement; and new tools to manage the evolution of resistance in pests, pathogens and weeds.
- Lead to integrated solutions and new crops to minimise pollution of air and water.
- Reveal what constitutes a 'healthy' soil and how to sustain it.
- Allow the replacement of chemical treatments for animal diseases with safer and more environmentally friendly alternatives, such as vaccines and selective breeding.
- Provide new control strategies and vaccines for animal diseases based on a better understanding of host/pathogen interactions.
- Lead to new ways of suppressing plant diseases or improving growth by exploiting the interactions between plants and microbial communities.

Animal Health and Welfare

The Institute for Animal Health (IAH) is a major national and international centre for research on diseases of farm animals and has unique disease containment and other facilities. IAH hosts world, EU and regional reference laboratories for a number of diseases and its work provides vital support to Defra through independent scientific policy advice, disease surveillance, diagnosis and response to disease outbreaks. It is not possible to predict what spectrum of diseases will be significant in ten years so IAH will maintain its strategic capacity and flexibility to work on a range of pathogens, focusing mostly on those of cattle and poultry.

IAH and RI will work more closely together over the next decade to pioneer the use of genomics data on farm animals and their pathogens to provide a greater understanding of host/pathogen interactions at the molecular, cellular and whole animal level. This will identify new disease resistance traits that can be introduced through animal breeding programmes, as well as new strategies to control, prevent or limit infections. Linked to this will be practical advances in rapid and accurate detection of infections, improved vaccines and better surveillance. Technology development of this kind, and more broadly across other areas of activity, is an important deliverable from institute research.

In future, RI will be a leading contributor to the Edinburgh Bioscience Research Centre (EBRC)[8]. Partners in the EBRC have complementary interests and RI's distinctive contribution will be in animal genetics, in particular quantitative genetics, genomics bioinformatics and genetic modification. RI will have a key role in improving animal welfare through selection to improve resistance to infectious and non-infectious disease or against traits such as feather pecking in chickens.

Livestock genomics; G3 Autoloader used for selecting individual genes from large libraries and preparing filters of libraries

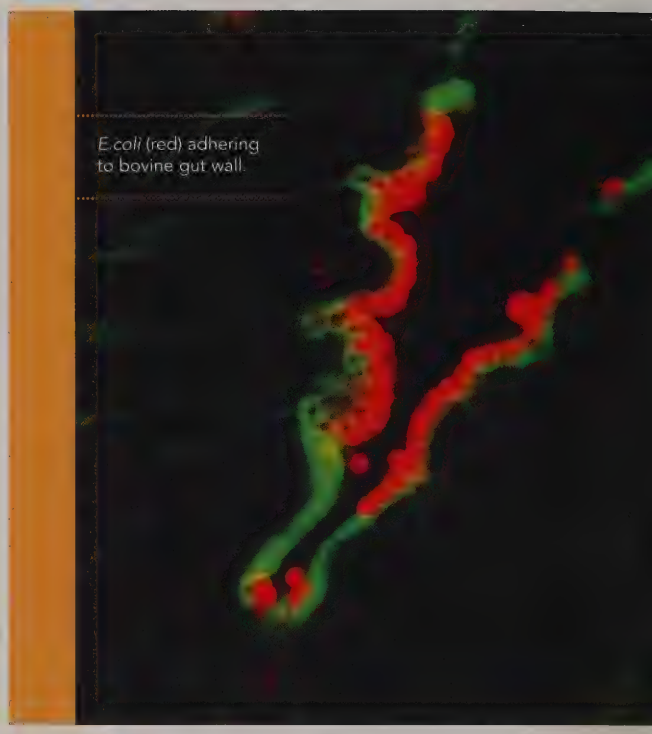
[5] Eurostat Data.
[6] Meat and Livestock Commission figures, includes all meat, eggs and milk.
[7] Economic cost of foot-and-mouth disease in the UK. A joint working paper by Defra / DCMS, March 2002: www.labouranimalwelfaresociety.org/files/fmdeconcost.pdf
[8] EBRC is a strategic alliance between Roslin Institute, Scottish Agricultural College, Moredun Research Institute, IAH Neuropathogenesis Unit and the Royal (Dick) School of Veterinary Studies and the University of Edinburgh, to create a new centre for animal bioscience. The aim is to provide increased critical mass, centralised resources, rationalisation of animal resources, complementarity of expertise, and the mutual advantages of university and institute-led research.

The ability to work with pathogens of farm animals in their target host in disease-secure facilities is a major strength of IAH, and lacking in the university sector. This strategic capability will be protected and enhanced as will our national capability to conduct research on exotic viral diseases – such as foot-and-mouth disease – in high containment. The redevelopment of the IAH Pirbright laboratory in partnership with Defra will provide state of the art facilities amongst the best in the world to work on exotic viral diseases of farm animals. This programme makes a valuable contribution to the UK's efforts in the developing world as diseases exotic to the UK are often endemic in these countries. Control of diseases in developing countries not only safeguards the UK but also provides important overseas aid.

Strong programmes in immunology and vaccinology at IAH, focusing on cattle and poultry, are extending understanding of immune responses to infectious agents. This will be complemented by studies to understand how specific pathogens interact with their animal hosts at the molecular level to establish infections, including the mechanisms used by pathogens to subvert immunity by disrupting host cell signalling pathways. An important disease-causing bacterium under study at IAH is *Mycobacterium bovis*, the causative agent of bovine tuberculosis. This disease is a serious cause for concern for UK livestock farming both economically and also with regard to welfare. The possible role of the badger in the transmission of bovine TB also introduces an environmental element to this problem.

The potential contribution to disease control of genetic variation in the host responses, including disease resistance, has not yet been fully exploited in farm animals. RI scientists will explore this genetic potential in joint programmes in collaboration with IAH and others. RI research on the genetics of host responses to infectious disease includes studies in all major farm animal species (cattle, sheep, pigs and poultry) as well as in some farmed fish species and addresses all the major pathogen classes – viruses, bacteria, parasites and TSEs.

We need to understand more about the likely opportunities and threats to UK farming and food production posed by climate change. For example, several important exotic viral diseases of livestock studied at IAH are carried by insect or tick vectors that with climatic changes could pose an increasing risk to Europe including the UK. Scientists at IAH are working on the biology of the bluetongue virus, which since 1998, has been expanding its range further north and west, probably due to shifting climate around the Mediterranean.



Managing food safety and avoiding contamination by pathogenic microorganisms requires a 'whole food chain approach' that begins in farm animals (IAH) and ends in the food processors and retailers. Research at IAH will focus on the basic biology and host interactions of animal pathogenic microrganisms. Recent work is revealing possible relationships between nutrition, stress and susceptibility to infection in animals. There is evidence that *E.coli 0157* attaches itself to the gut of cattle in response to the presence of a stress hormone in the animal's gut. Studies at IAH on *E.coli 0157* and other bacteria such as *Salmonella* that cause zoonotic infections (infections that can be transmitted to humans) has immediate relevance to human health (see page 14). Institute of Food Research (IFR) research will provide a better understanding of the behaviour of bacterial pathogens in food and improve prediction of their response to different food environments. The vision is to eliminate existing pathogens from the food chain and prevent emerging bacteriological food safety problems.

Over the next ten years research at BBSRC institutes on animal health and welfare will:

REWARDS

- Improve diagnostic tests for the detection and identification of important diseases of animals.
- [illegible] for animal diseases, based on a better understanding of host/pathogen interactions.
- Reduce the incidence of zoonoses such as food poisoning.
- Improve animal welfare by the better prevention and control of infectious and non-infectious diseases.
- Lead to the identification of disease resistance traits for [illegible]
- Provide new genomics tools to accelerate the pace of selective breeding of livestock.
- Improve surveillance of new diseases that through a combination of factors, such as climate change, now threaten the UK.
- Improve the UK's ability to respond to disease outbreaks – i.e. foot-and-mouth disease.

Biomedicine related to human well-being, including food safety and diet & health

See BBSRC's Strategic Plan sections Integrative Biology, Healthy Organism, and Bioscience for Industry
www.bbsrc.ac.uk/about/pub/policy/strategic.html

BBSRC's remit encompasses a broad range of bioscience of relevance to improving the health and well-being of people, including the influence of diet on health. The knowledge and skilled people that this investment generates in the research base is taken up by others to underpin advances in clinical research and healthcare. The strength of the UK's bioscience base is one of the reasons that big multinational pharmaceutical companies are based and invest here. Of the many challenges facing modern Western societies few are more immediate than the drive to stay healthier longer as our population ages. Diet-related health issues such as obesity, diabetes and some cancers are on the increase. There is also a growing awareness of food safety, particularly of food-borne pathogens, such as *E.coli 0157* and *Salmonella*. Bioscience will have a major contribution to make in providing solutions to these and related problems. BBSRC institutes provide the mission-focus and critical mass that are necessary to make significant advances in these areas.

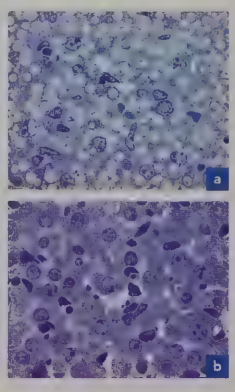
Cellular and genetic basis of health

Research at Babraham Institute (BI) is aimed at understanding the complex mechanisms of cell signalling and gene regulation that underlie normal cellular processes and development. This includes identifying how their failure or abnormality can lead to disease. The institute provides international leadership in the areas of cell communication and signalling and in epigenetics[9]. Over the next ten years BI will focus on strengths in functional cell biology, and in particular on understanding more about signalling pathways in processes such as inflammation, antibody production and early vertebrate development.

Pioneering work at BI on epigenetics and imprinted genes (those genes whose expression depends on whether they come from the father or the mother) will reveal more about the underlying biological control of gene expression. The study of gene imprinting will be a strong driver for brain and behaviour research in the future; faulty imprinting is probably associated with a number of common mental disorders. Understanding the principles of epigenetic gene regulation will also shed light on the developmental origins of optimal health, including the influence of diet and nutrition in early life (including before birth).

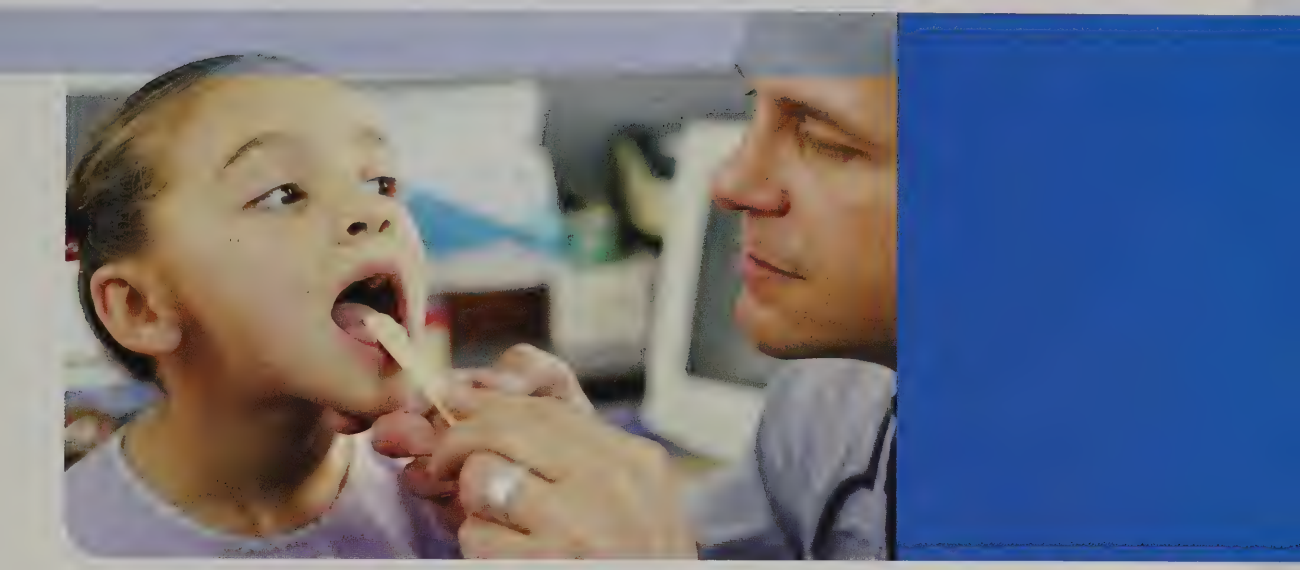
The DNA in cells is tightly packaged with proteins in a condensed form known as chromatin. Babraham will build on its lead in investigating gene regulation by studying chromatin 3-D organisation, function and remodelling. Before genes can be expressed it is essential that the chromatin structure is remodelled (unwound) to give the cellular machinery access to individual genes. The active genes often loop out of their immediate position on chromosomes to gain access to localised gene expression hotspots or 'transcription factories' in the cell nucleus. Cutting edge work at BI has shown that transcription factories are visited at the same time by many active genes often separated by great distances along chromosomes. Research such as this will provide further pieces to the jigsaw of precisely how genes are expressed in an orchestrated way during cell development. It will have implications in many fields, ranging from better understanding of stem cell differentiation, to ageing research and the factors affecting cancer cell proliferation.

Unravelling the complex genetic regulation and signalling pathways that enable a single fertilised egg to develop into a multi-cell, multi-tissue, multi-organ organism; and that enable animal body shapes to change during evolution, remains a major challenge in basic bioscience research. It is also of enormous strategic importance because defects in these processes are responsible for a wide range of disorders and conditions including some cancers. BI researchers have investigated the regulation and function of *Hox* genes – part of a family of genes responsible for laying down the basic body plan of developing embryos. Going forward, BI will initiate work in a related area; namely, the mechanisms and functions of the signalling pathway that involves the protein called Hedgehog, which plays a key role in controlling how cells become organised within different tissues in developing embryos.



Profound lean phenotype of mice lacking the imprinted gene *Gnasxl*. Sections of brown adipose tissue from wild-type (a) and *Gnasxl* mutant (b) neonatal mice reveal complete depletion of stored lipid caused by over-stimulation of the tissue in the mutant. Image reproduced from *Plagge et al.* The imprinted signalling protein XLas is required for postnatal adaptation to feeding. *Nature Genetics* (August 2004) 36:818-826

[9] Epigenetics describes a range of heritable characteristics that are independent of changes in DNA sequence.



Novel therapeutics and treatments

There is an urgent need for new antibiotics to combat organisms such as MRSA that are resistant to conventional treatments. Scientists at JIC and IFR are collaborating with Novacta Biosystems Ltd. to develop new natural and synthetic antibiotics. Each institute has specific expertise in this area of microbial chemistry and biology. JIC will build on its world-class work with *Streptomyces coelicolor* where detailed analysis of the genome and understanding of how natural antibiotic synthesis is regulated is revealing enormous potential for the production of many more novel bioactive molecules. Likewise, studying bacteria in their natural environments (as opposed to laboratory cultures) is revealing many new molecules not seen in culture. IFR leads research on the natural lactic acid bacteria, which are a vital positive component in the gut microflora of humans and other animals. Some of this research crosses over the food-pharmaceutical boundary and could provide novel antibiotics and delivery systems for vaccines and other biologically active molecules.

Work at BI on gene regulation (above) will further our ability to predict and control the specialisation of stem cells into specific cell types and will be crucial if they are to fulfil their therapeutic potential as cell replacements for conditions such as Parkinson's disease.

The immune system is responsible for protecting the body from infection and disease. Antibodies are secreted by white blood cells – B lymphocytes – while a second class of cells – the T lymphocytes – helps to orchestrate immune responses. T lymphocytes can recognise a previous encounter with an invader and mount a quicker response to subsequent infections. Occasionally, lymphocytes are produced that react with the body's own cells, giving rise to autoimmune disease. Research at BI will help to reveal more about the development and activation of lymphocytes and other cells of the immune system. This knowledge will be essential to develop new therapies based on a greater ability to modulate the immune system in health and disease.

Human medicine will continue to benefit from research at IAH and RI on large animals as models for human systems. At RI studies on model species will be important to understand basic biology, with cattle and sheep for example being the most appropriate models for human female reproduction and prenatal factors that can affect development of offspring. Similarly the chicken is an excellent model for vertebrate development.

A number of livestock diseases studied at IAH have human correlates e.g. respiratory syncytial disease, BSE and scrapie, *Salmonella* infection, and TB. Understanding the disease and the protective immune responses in natural animal hosts will aid our understanding of the disease in humans. This is also true for disorders with a genetic basis where studies on affected animals can illuminate the equivalent human conditions. With the genome sequences of an increasing number of farm and other animals becoming available, comparative genomics will be a powerful tool to study gene function in humans and animals. New animal models are needed to improve the safety evaluation of new therapies and innovative approaches are needed to improve the reliability and usefulness of *in vitro* cell based alternatives.

Diet & health

Food is a complex mixture of nutrients and bioactive components that are intimately involved in the maintenance of health. BBSRC-funded research on diet and health has a vital and unique role in helping to understand the molecular, cellular and whole body mechanisms by which humans respond to diet, and the consequences of diet-related processes that can lead to chronic disease. Post-genomics techniques now provide an unprecedented opportunity to develop early biomarkers of risk and identify dietary constituents and patterns that can slow or halt progression to disease, thereby improving quality of life and reducing reliance on costly drug treatment in the ageing UK population.

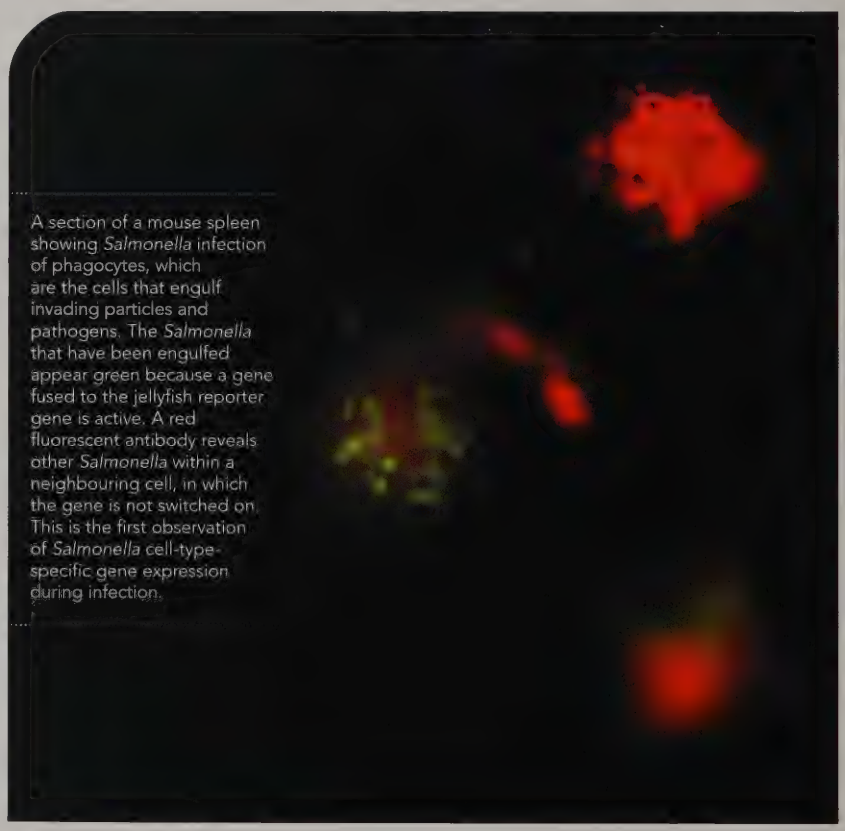
Over the next ten years, research at IFR will focus on understanding the human gut as an integrated system, influenced simultaneously by signals from food components, systemic metabolism and an immensely complex gut microbial community. This research will define how microbial communities play a central role in the maintenance of GI tract health, and lead to an understanding of the use of commensal bacteria to prevent and cure diseases and to eliminate human pathogens from the food chain.

Gut/food interactions will contribute enormously to a better understanding of the immunological basis of food allergies, where the goal is to identify mechanisms involved in the early stage of sensitisation to certain food components and to identify why some foods, such as peanuts, are more allergenic than others. This knowledge will support more effective allergen risk management as well as the development of reduced allergen foods.

In developed nations diabetes and obesity are increasing. Epidemiology supports a link between diet and cardiovascular disease and increasing incidence of cancers such as colorectal carcinoma and oesophageal adenocarcinoma. In order to understand and prevent the promotion of colorectal cancer by western diets it is essential to establish how and why the vulnerability of the mucosa increases during the decades prior to the emergence of lesions. Research at IFR will focus on epithelial biology, with particular emphasis on nutrition and gut bacteria in early precancerous changes in the colon and oesophagus, and on the role of cell proliferation and apoptosis in the maintenance of epithelial 'health'. This work is complementary to that at BI on inflammation.

Diseases from animals

Zoonotic infections (those that can pass from animals/livestock to people) are a major risk to public health. They include transmissible spongiform encephalopathies (for example, BSE/vCJD), avian influenza, SARS (which is caused by a coronavirus), *Salmonella* and *E.coli 0157*. IAH has a major programme on zoonotic agents which aims to understand more about the pathogens and carrier status of the hosts and to identify means of detection and control of the agents. The aim is to control infections within animals and thereby reduce transmission to humans. IFR scientists work on the biology of major food pathogens, and are studying the survival of bacteria in the gut. IAH and IFR will build collaborative research on infection via the GI tract.



A section of a mouse spleen showing *Salmonella* infection of phagocytes, which are the cells that engulf invading particles and pathogens. The *Salmonella* that have been engulfed appear green because a gene fused to the jellyfish reporter gene is active. A red fluorescent antibody reveals other *Salmonella* within a neighbouring cell, in which the gene is not switched on. This is the first observation of *Salmonella* cell-type-specific gene expression during infection.

Over the next ten years research at BBSRC institutes on biomedicine related to human well-being and diet & health will:

REWARDS

- Unravel the process and control of infection and inflammation from the study of basic cell biology and signalling cascades.
- Provide a better understanding of epigenetic processes in brain function.
- Provide a better understanding of stem cell development and reprogramming.
- Define how diet can affect pre-cancerous changes in the gut mucosa and the interaction with gut microflora.
- Provide science-based options to reduce the incidence of food poisoning.
- Lead to Smart probiotics which will reduce food allergies, food intolerances, inflammatory disease and incidence of cancer.
- Improve the treatment of allergies and inflammatory diseases related to diet.
- Deliver new ways of combating infectious diseases from a deeper understanding of immune cells.
- Identify novel bioactive molecules (e.g. antibiotics) from microorganisms, invertebrates and plants through bioinformatics, metagenomics and high throughput assays.
- Help to better identify 'vulnerable' groups and individuals with specific dietary requirements so as to reduce the risk of disease.
- Provide a deeper understanding of normal human processes such as immunology of infection and female reproduction and foetal development – and what happens when they go wrong – based on large animal models.

Partnerships

BBSRC institutes will continue to work in partnership with a variety of stakeholders – both nationally and internationally.

The institutes operate mixed economies where they win research funding from a variety of public and private sector organisations. Research funders such as industry or Government Departments gain much benefit from funding applied research within an institute environment of more basic 'fundamental' studies. IFR researchers have received funding from ICI's strategic research fund to investigate synergistic starch blends; taking advantage of the Institute's expertise in understanding the relationship between biopolymer behaviour and material properties. Another example of benefit derived from applied research in the setting of more basic/fundamental science relates to that of the Farm Scale Evaluations of GM herbicide tolerant crops. Expertise at RRes in experimental design and analysis coupled with the ecology of agricultural systems enabled Defra to carry through the well-publicised FSE programme that impacted on EU and UK policy decisions.

Institutes work closely with stakeholders who make use of the knowledge and know-how that the research generates. This provides institutes with a deeper understanding of the needs of the research user communities, thus helping to guide priority setting and ensure highly relevant research. Research at RRes into resistance of fungal pathogens to certain commonly used fungicides was informed by a LINK consortium of agrochemical suppliers, ADAS and Defra's Pesticide Safety Directorate to ensure that the work was directed towards the major challenges facing farmers, regulators and suppliers.

Increasingly the multidisciplinary nature of institute research means that they need to work closely with universities and other Research Councils; in particular the Natural Environment Research Council (NERC) and the Medical Research Council (MRC) (or their institutes and units). This trend will continue and BBSRC will work with the other Research Councils to ensure that any unnecessary barriers to joint funding and collaboration are removed.

Science in Society – 'a public partnership'

The institutes are well placed to show how advances in fundamental bioscience research lead to practical outcomes, and to contribute to public debate about future directions, and applications and implications of research.

They have a strong tradition of publicising their activities through the media, and of playing an active part in their local communities, for example through links with schools and by holding open days, discussion meetings and exhibitions. Institute staff serve on a variety of regulatory and advisory bodies that address wider social issues associated with bioscience research.

Going forward, the institutes, independently and in partnership with BBSRC, will increasingly develop opportunities for dialogue activities such as the joint BBSRC-IFR assessment of research priorities 'Public attitudes towards BBSRC-funded research into diet & health' that was carried out in 2005. This will enable them to take account of public attitudes, aspirations and concerns, in formulating their research plans and engagement activities.

International partnerships

Each of the overarching strategic areas of institute research (see page 4) requires international collaborations and partnerships to meet the complexity of the challenges and to further enhance UK scientific excellence and competitiveness. The institutes have a range of international activities and partnerships – both in developed and developing nations – and they remain some of the most sought after destinations for visiting overseas scientists.

The Aberystwyth Science Café organised by IGER.

Lin Field from Rothamsted Research was recently awarded an Honorary Professorship while on a visit to the Nanyang University in China to sign an agreement to establish a new Nanyang-Rothamsted Joint Laboratory for Insect Biology.

Institutes are pro-active in helping to set EU research agendas and will build on their high level of participation in EU Framework Programmes, thus helping to keep the UK at the forefront in Europe. When Framework Programme 7 (FP7) starts in 2007 there will be many opportunities for collaborative research through themes such as health, environment and food, agriculture and biotechnology. FP7 will also create a budget for the first calls for proposals from a European Research Council: research proposals from BBSRC institutes will be in competition with the best from across Europe. Framework Programmes continue to support collaborative research for international development and for training through the Marie Curie programme. The high level of institute activity as a host for Marie Curie fellows is an international measure of esteem of research, training and facilities in institutes. Other international programmes such as the Human Frontiers Science Program will offer the opportunity for research funding beyond the EU, and opportunities will further exist as BBSRC funds research with other organisations e.g. through EU ERA-Net consortia.

Influencing the EU research agenda beyond Framework Programmes creates unique opportunities for taking forward institute research programmes in a European, and frequently global, context. Institutes will further their participation in Technology Platforms such as *Plants for the Future* and *Food for Life*, creating durable partnerships between research, industry and consumer sectors with policy makers and research funders.

The institutes have a long history of research collaborations with developing countries and there is great potential for science and technology to facilitate sustainable international development and help meet Millennium Development Goals. Institutes will continue to deliver research and training for the developing world drawing on their expertise and experience. Establishing links and co-operation with China and India, both emerging centres of world-class research and innovation, will be particularly important.

Knowledge Transfer and Innovation

BBSRC institutes have a diverse range of effective knowledge transfer mechanisms to ensure that UK society and the economy capture the benefits of their research and unique expertise. Over the next ten years the institutes will increase KT activity in four main areas:

Evidence based policy, economic performance and the 'public good'

The coincidence between government policy, economic performance of certain sectors of the UK economy (notably the land-based industries) and the delivery of environmental goods and services represents a 'win-win-win' for investment in bioscience.

Institute research is essential for the development of evidence-based policy by Government Departments, particularly Defra and the FSA. Whilst the extent of research conducted by the institutes to inform policy over the coming decade will depend to a significant extent on availability of departmental research funds, the need for such work is likely to increase. The main drivers for this include:

- Changes in agricultural practice and economics within Europe and globally.
- Demand for more sustainable land management practices.
- Requirement to develop effective preventative strategies against diseases of both animals and crops.
- Increasing consumer awareness of the link between diet and health and concerns over food safety.

There will be a continuing need to pursue knowledge transfer mechanisms that demonstrate and achieve implementation of best practice. This is particularly important in the land management sector – for example by the extension-type activities undertaken by IGER and RRes engaging directly with farmers and growers. This form of knowledge transfer simultaneously impacts positively on the economic performance of a valued industrial sector (see page 2) while delivering Government policy alongside the environmental goods and services increasingly demanded by UK society.

Close interactions with the large number of small food producers and manufacturers is also essential to encourage take-up of new ideas which could improve competitiveness. This sector currently represents 8% of UK GDP. IFR will enhance its ability to network with the sector where already its Food and Health Network is valued by the industrial community. Animal health and breeding companies will continue to benefit from the Genesis Faraday Partnership in which IAH, and particularly RI, are heavily involved.

The Babraham Bioincubator

Collaborative research with industry

The agriculture and food industries have traditionally been low spenders on R&D but collaboration and contract work with BBSRC institutes has provided an effective way of engaging expertise and access to facilities. The LINK scheme has been, and will continue to be, a key mechanism to support joint projects. In addition there is likely to be increasing interest from the pharmaceutical industry for institute research related to human well-being and diet and health, where in particular BI and IFR will grow their industrial revenues.

Overall industrial income to institutes for research contracts and collaborations was £12.6M in 2003-04 and, whilst significant growth in the short-term may be difficult for some sectors such as agriculture, over the next ten years the institutes plan at least a 50% increase in industrial income; underpinning the Government's objective of encouraging further industrial investment in R&D to enhance national research spend as a proportion of GDP to 2.5%.

Intellectual Property Management

Over recent years all of the BBSRC institutes have enhanced their capabilities to recognise, protect and manage Intellectual Property (IP) arising from their research. Indeed BBSRC institutes won 50% of the £15M available at the last round of the PSRE fund[11] (January 2005) aimed at enhancing exploitation in public sector research establishments. There have already been a number of notable successes including the development of the Paracox vaccine for the control of coccidiosis in chickens from research undertaken at IAH, which has secured over £1M in royalties. IGER, through plant breeding rights, has a stake in some 70% of the UK oat seed market and many of the institutes have already had success in launching spin-out companies.

Over the next ten years institute IP portfolio management will be increased, which is already occurring via the BBSRC-supported exploitation company, PBL, across the four institutes involved in plants, crop and microbial sciences. No targets are set for spin-out company formation or growth of licensing income in order to avoid perverse incentives, but exploitation will be increased over the coming years and monitored through bi-annual business plan meetings with the institutes and BBSRC, and through a four-yearly knowledge transfer assessment exercise.

Regional Economic Development

Finally, the institutes have a significant role to play in contributing to regional economic development. Already many of the institutes have strong links with their Regional Development Agencies (RDAs) and counterparts in the devolved administrations, with the BI, JIC and RI having received support to develop bioincubator facilities and IGER to develop (with the University of Wales) a Technology Innovation Centre. The facility at BI (see opposite) is perhaps the UK's most successful bioincubator with developments well advanced to provide laboratory and office accommodation for companies as they mature, yet near to the expertise and high-level resources which the Institute can provide to help sustain growth. Whilst BBSRC as a parent organisation has national responsibilities, the institutes will continue to engage strongly with RDAs in regional economic development where there are common goals and interests.

[11] The PSRE fund was launched by OST in response to the 1999 Baker report on realising the economic potential of public sector research establishments. The funds are available to help such organisations develop their capacity to exploit their science and technology potential and to provide seed funds for business formation. See www.ost.gov.uk/research/funding/budget05-08/allocations.pdf for the OST allocation booklet.

Highlights: institute science

The following pages show some of the science highlights from BBSRC institutes over the last ten years. Most of the examples illustrate the typically longer-term, multidisciplinary and strategic nature of the research. In other cases, it is the focus of expertise and research effort or unique facilities that the institute environment provides which have been major contributory factors to the success.

Establishing

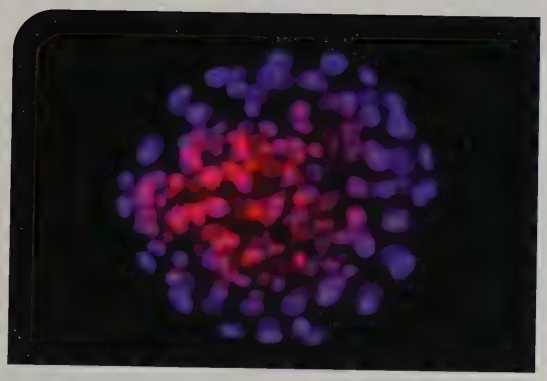
the genome sequence of a major pathogen of chickens

The Institute for Animal Health provides a significant concentration of expertise for the UK in infectious diseases of animals. Building on this expertise, and in collaboration with the Wellcome Trust's Sanger Institute, IAH scientists have established the genome sequence of *Eimeria tenella*, which causes coccidiosis in chickens. *Eimeria spp* are related to the pathogen that causes malaria and are a major source of disease and welfare problems in farmed birds and which costs the UK industry at least £40M per year. The *Eimeria* genome is now the basis of a major multidisciplinary programme to develop new and more sustainable treatments for coccidiosis.

Detection

of a new animal disease threat to UK

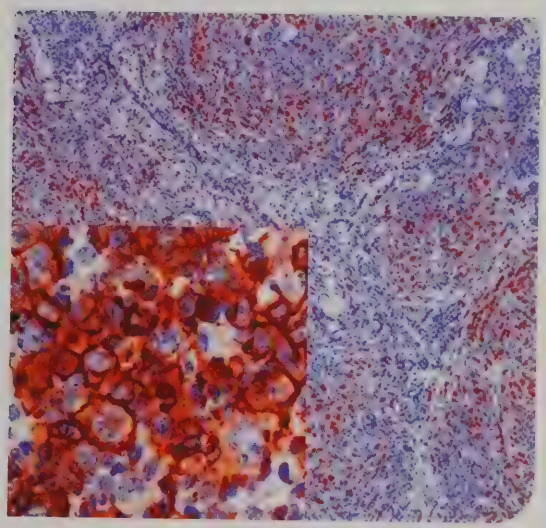
As part of the long-term studies of viral diseases conducted by researchers at IAH it has been shown that the incidence of bluetongue virus (causal agent of bluetongue, an economically important disease of sheep) is moving north through Europe. This is correlated with the expanding range of its midge vector. Climate change is implicated in the expanding range. Furthermore, drawing on IAH's expertise with invertebrate vectors of disease, as well as the disease-causing agents themselves, it has been shown that a UK midge species is capable of harbouring and transmitting the bluetongue virus.



New targets

for anti-cancer and anti-inflammatory therapies

Scientists at the Babraham Institute have made fundamental advances in our understanding of the processes by which growth factors, antigens and inflammatory stimuli regulate mammalian cell responses. This has led to a new model for membrane/protein interactions and identified important new targets for anti-cancer and anti-inflammatory therapies and drugs.



Understanding

factors that can increase susceptibility to heart disease, diabetes and psychiatric disorders

Pioneering work at the Babraham Institute has shed new light on gene regulation via the mechanism of imprinting or epigenetics. A characteristic of Babraham research is that it brings a sharp focus to a small number of critical areas of cell and molecular biology. In this case, the focused effort has begun to unravel the complex epigenetic factors that can have a large impact on growth and development. For example, there is strong evidence now that nutritional and other stresses in the womb can increase susceptibility to heart disease, diabetes and psychiatric disorders later in life.

Identification

of chemicals from food that can help to protect against cancer

The combination of expertise in nutrition, the gastrointestinal tract and the structure and composition of food at the Institute of Food Research has supported research which has shown how chemicals, such as isothiocyanates, created during the preparation of some vegetables, particularly Brassicas, could destroy colon cancer cells. In related work, the food components sulforaphane and selenium have been found to work synergistically to protect against cancer. They activate enzymes that destroy carcinogens, reduce cell proliferation and protect against oxidative stress.

Highlights: institute science

Control
of witchweed in East Africa

The African witchweed, *Striga hermonthica*, is a significant parasitic weed of maize and other cereals on many resource-poor farmsteads in East Africa. A multidisciplinary collaboration between biological chemists at Rothamsted Research and African agricultural researchers has developed a novel practice of intercropping the cereal crop with species of *Desmodium* which is a legume that suppresses witchweed. The cropping system has the advantage of being low input (no expensive chemicals involved) and the *Desmodium* can be used to provide forage for cattle.

More efficient
and sustainable animal production with high sugar grass

The Institute of Grassland and Environmental Research is the only UK institution that combines expertise in farm animal, plant and microbial science. This particular focus of expertise has demonstrated that new forage varieties with higher amounts of sugar in the leaves can improve the efficiency of animal production. Increasing the concentration of soluble sugars improves the balance of nutrients released during initial colonisation in the rumen and this enhances the efficiency of conversion of forage to microbial protein. In animal trials, high-sugar grasses consistently increased the nitrogen use efficiency of dairy cows (from 23 – 35%) by reducing excretion of Nitrogen in urine.

Publication
of the genome sequence of the bacterium *Streptomyces coelicolor*

Building on a history of research into soil microorganisms, scientists at the John Innes Centre and the Sanger Centre have published the genome sequence of *Streptomyces coelicolor*. These common soil bacteria are the source of half the world's antibiotics. *Streptomyces* are harmless relatives of the bacteria that cause tuberculosis, leprosy and diphtheria. With the new genome sequence, many common features of all four genomes have been revealed and comparative studies with *Streptomyces* will provide new insights into these infamous diseases. Understanding more about the genes that regulate antibiotic production has provided fresh insight into the synthesis of new drugs to combat bacteria that have become resistant to current treatments.

Nature, May 2002, volume 417 (6885)

Identification

of the 'green revolution' gene

Recent work at John Innes Centre has used a model plant *(Arabidopsis)* to help identify the natural genetic mutation that causes dwarfing in some plants and to understand its function. Selection for this mutated gene in wheat in the 1970s led to the dramatic increases in wheat yields – the so-called 'Green Revolution'. The productivity of wheat was increased by the production of short (dwarf) varieties, which put proportionately more of their energy into making grain than into producing stem. Building on the JIC work, similar genes in rice and maize are now the targets of major plant breeding programmes.

The Farm-Scale Evaluations:

science into policy

Researchers at Rothamsted Research were amongst those responsible for carrying out farm-scale evaluations, commissioned by Defra, to assess the impact on biodiversity in agricultural ecosystems of weed control using GM herbicide-tolerant forage maize, beet and oilseed rape. The long timescale, large field area and the need for experienced researchers to collect and analyse data meant that Rothamsted was well placed to carry out such work. The results of these trials are vital in forming UK and EU policy regarding the cultivation of GM crop varieties.

Reducing

phosphorus pollution from farmland into water

The Institute of Grassland and Environmental Research has unique field-scale facilities to study the movement of nutrients and pollutants through livestock-based land use systems and to model their impacts on soil, water and atmosphere. Research as IGER has shown that phosphorus release from soils increases significantly following drying and rewetting. The amount of organic phosphoros released is related to the microbial phosphorus content prior to drying. This type of movement is a significant component of phosphorus pollution from farmland into surface and other water bodies. Understanding the factors that influence phosphorus release from farmland is helping to develop farming practice to reduce this source of pollution.

Highlights: institute science

Production
of Dolly the sheep

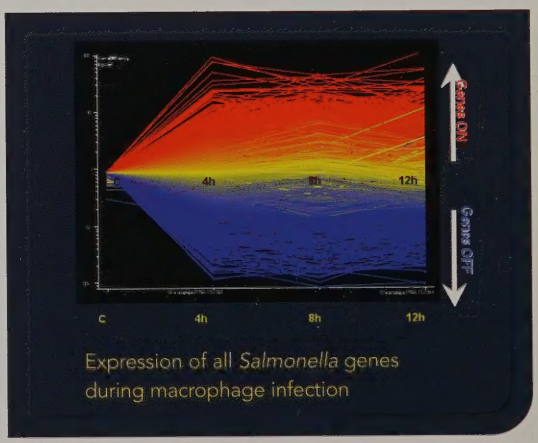
A long-term research programme at the Roslin Institute on mammalian transgenesis, the cell cycle and nuclear transfer paved the way for the production of Dolly – the first demonstration of mammalian cloning from a differentiated adult cell. Her birth represented a remarkable breakthrough in biology because it showed that the nucleus from a differentiated cell could lose its specificity and function like that of a newly fertilised egg.

Anti-cancer
antibody made in chicken eggs

Roslin is the UK's leading institution for the production and study of transgenic farm animals. It has expertise that is unrivalled in the university sector; many of the technologies for making transgenic animals and cloning were pioneered at Roslin. Building on this focus of research Roslin has, with partners Viragen Inc. and Oxford Biomedica succeeded in obtaining a functional human antibody protein in the whites of chicken eggs laid by a transgenic hen. This technology is expected to offer a low cost manufacturing alternative for the production of many high quality and valuable protein drugs.

National resource
for *Salmonella* research

The Institute of Food Research provides researchers in the UK with an unparalleled focus on all aspects of food research, allowing scientists to address key strategic concerns of food safety. Research at IFR has identified hundreds of novel *Salmonella* genes that may be important during infection and provided insight into how *Salmonella* adapts to when it infects cells. They have generated a compendium of gene expression profiles of *Salmonella typhimurium* exposed to various conditions reflecting either the conditions inside host cells or environmental stresses encountered in the food chain.



Expression of all *Salmonella* genes during macrophage infection

Institute Governance, assessment and development

BBSRC regards its sponsored institutes as providing an important strategic science capability for the UK mainly in areas which are not readily found in universities. The Council recognises the importance of good consistent governance and critical assessment of institute performance. There is also the need for strategic review periodically which may involve hard decisions about consolidation and rationalisation across some institutes in order to reinvest in other areas.

Governance

Each institute is an independent company limited by guarantee and a registered charity. Staff are all employed on BBSRC terms and conditions and most, but not all, sites are leased from BBSRC to the institute.

The Governance of each institute is defined by a Memorandum and Articles of Association and a Conditions of Grant agreement with BBSRC. Each institute has a Governing Board, with which BBSRC works in a partnership that recognises their independence and legal responsibilities. The members of Governing Boards are chosen largely for their academic or business backgrounds and are a valuable source of advice for the institutes. They are non-executive directors of the company and trustees of the charity. Advertisements are placed for expressions of interest to serve as Board members. Nominations are drawn from the responses received as well as suggestions from the institutes themselves.

BBSRC's Chief Executive, as Accounting Officer, has responsibility for institute operations as they are largely publicly funded and BBSRC acts as banker of last resort. Each institute operates its own audit committee, which receives reports from external auditors, Research Council internal auditors and oversees the institute's risk management arrangements.

Assessment

A leading priority for BBSRC is to ensure that institute research is of a high quality and fit for purpose. The institutes are subject to a rigorous review every four years through the Institute Assessment Exercise (IAE), the procedures for which match the best practice identified in the quinquenial review of Research Councils in 2001.

The IAE has a number of strands of assessment:

- The quality and relevance of the research.
- The institute's achievements and future plans in promoting knowledge transfer (KT).
- The training of students and fellows.
- Institute contribution to, and plans for, Science in Society activities.

All aspects of the assessment are based on peer review; Visiting Groups spend up to four days at the institutes to assess the quality and relevance of the science and the institute's plans for science in society activities. Separate panels assess KT activities (and future plans) and studentships and fellowships training (SFT). Where appropriate input is sought from other major funders, particularly Defra and FSA. Visiting Groups and the panels for KT and SFT assessment include members from academia, industry and the international community.

The results of the IAE are key in setting the Core Strategic Grant to each institute for the following four years. Institutes also receive extensive feedback on performance.

Development – a dynamic institute base

Historically (post 1950) BBSRC and its predecessor organisations (ARC and the AFRC[12]) sponsored a larger number of institutes than the current seven. Over the years there has been an evolution of the institutes which continues to the present day driven by the needs of the science and the added value achieved by concentrating critical mass of research effort in particular strategic areas. Some recent examples of how the institutes continue to develop are:

- Following the 1996/7 IAE Council took the decision to rationalise the activities of IFR on a single site at Norwich; the site at Reading was closed.
- Following the 2001 IAE a similar rationalisation process was applied to RRes with the closure of the Long Ashton site and investment of £19M in state of the art laboratories in the Centenary building on the Rothamsted site.
- Following review of the IAH-Pirbright Laboratory in 2002, Council agreed to the redevelopment of the site to provide, in partnership with Defra, world-class containment and research facilities. The total cost of the new build will exceed £120M, with BBSRC providing £23M.
- Following a detailed review of the work of the Silsoe Research Institute in 2004, Council explored the options for a merger with another organisation or institution. When this was not possible Council took the decision to withdraw core funding after March 2006. Those aspects of research at Silsoe considered to be world class have been transferred to other organisations.

Over the next decade the institute base will continue to evolve in ways that will enhance the quality and delivery of the necessary research. There will be an emphasis on increasing partnerships; partnerships both between BBSRC institutes (e.g. cross-institute programmes) and more collaboration with the institutes/units of other research funders such as NERC and SEERAD, especially in the area of sustainable agriculture and land use. More strategic partnerships are also anticipated between the institutes and leading universities – such as the involvement of RI, the IAH Neuropathogenesis Unit with Edinburgh University and others in the proposed Edinburgh Bioscience Research Centre, and the close association of IFR, JIC and the University of East Anglia in Norwich.

[12] Agricultural Research Council and the Agricultural and Food Research Council.

BBSRC
Polaris House
North Star Avenue
Swindon SN2 1UH

Telephone 01793 413200
Fax 01793 413201

www.bbsrc.ac.uk